

## Science through the looking glass of literature

Lecture given by

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on the occasion of the 430th anniversary  
of the Leiden University  
on Tuesday June 7, 2005



Mr. Rector Magnificus, ladies and gentlemen,

*'In this world, the passage of time brings increasing order. Order is the law of nature, the universal trend, the cosmic direction. If time is an arrow, that arrow points toward order. The future is pattern, organization, union, intensification; the past, randomness, confusion, disintegration, dissipation'.*

Much is known about Albert Einstein, but not what he was dreaming when he worked on the special theory of relativity. For Alan Lightman, physicist and writer of fiction, whom I have just quoted, this is an excellent opportunity to conjure up twenty-four theoretical realms of time, in as many fables dreamt in as many nights. All are visions that gently probe the essence of time, the adventure of creativity, the glory of possibility, and the beauty of the book *Einstein's Dreams*. In short stories of three to four pages each, Lightman creates twenty-four wonderful little worlds, worlds which Einstein may well have been analyzing, beautifully described with fascinating details; also unfolding short philosophies as we know them from Einstein's later writings.

In real life the effects of Einstein's relativity are so small that we do not notice them. The fascination of Alan Lightman's fiction is that he makes a link with our own surprising experiences and the enigmatic nature of time. These experiences have led to sayings such as: time flies, at all times, for the time being, in good time, out of time, at the same time, to make time, or to keep time, in no time, etc. For every one of them, Lightman has made up a short story, a dream. From one of *Einstein's Dreams* I have chosen to quote my favorite arrow of time. It's the arrow pointing toward order and as you will hear later, modern science teaches us that this dream comes true.

In 1987 on the occasion of the 150<sup>th</sup> anniversary of the literary journal *De Gids*, Hendrik Casimir one the big shots of twentieth century science in the Netherlands asked the following question. Suppose, in a few thousand years a future archeologist will be brave enough to start digging in the then still radioactive ruins of our civilization. And this archeologist would miraculously find a collection of poems but not any other books or manuscripts, would he get any idea of our civilization? Casimir put together a collection of poems from his favorite authors and concludes that there is such a big gap between literature and science that the archeologist would not at all get a truthful image of our society. "*Scientific knowledge is a substantial part of our knowledge, science based technology is an essential element of our material world. Is this also reflected in our poetry? I do not think so.*" Casimir concludes.

Casimir is not Komrij and perhaps it is worthwhile to start a search for modern science and technology in Komrij's collection of Dutch Poetry. But why should this search be limited to poetry? Why would the archeologist not find prose, fiction as well as non-fiction? From the start in 1837 the literary journal *De Gids* has published poetry, short stories and essays. It would be bad if one could only tell from the dates on the cover of this journal in what time its content was produced. Suppose Casimir's

archeologist would miraculously find all bound editions of *De Gids* of the twentieth century in good order, but not any other books, would our civilization and especially our science be reflected in this collection of literature?

To answer this question a bibliography of all articles on natural science in *De Gids* from 1900 to 2000 was produced. It contains as many as 929 articles from 340 authors, together 9000 pages of science, almost 8% of the total output of the journal in the twentieth century. From these, Rob Visser and I have chosen 60 essays and also a few poems, which we have put together in a book (*Trots en Twijfel, Kopstukken uit de Nederlandse natuurwetenschap van de twintigste eeuw*). The articles selected from the first half of the century reflect what some historians of science have called the Dutch Second Golden Age, with Nobel Laureates like Van 't Hoff, Van der Waals, Lorentz, Zeeman and Kamerlingh Onnes. In the second half of this century, the articles are more concerned with the revolutions caused by twentieth century science. Indeed, relativity, quantum mechanics and the Big Bang have dramatically changed our view of the world whilst the bomb, computers and lasers have radically altered world order. These developments in science are reflected by the non-fiction literature in *De Gids*. However, by limiting ourselves to essays on science from *De Gids* we have done only our second best, for we have not at all done justice to the full spectrum of literature and fiction in particular. Here I want to present a short anthology of science in literature.

My champion is Harry Mulisch because physics and astronomy play an important role in *The Discovery of Heaven*. In heaven one discovers that because of the development of modern science humans no longer believe in God but in humans only, therefore the Holy Alliance will be withdrawn. In a fantastic plot, which in human eyes may only be due to pure chance but in reality is guided by the invisible hand from above, the Ten Commandments return to heaven. In passing Harry Mulisch makes several “discoveries” in physics and astronomy worth analyzing.

It is well known that we do not see the milky-way as it is now but how it was some time ago, the time it takes for light to travel from the stars in the milky-way to us. Astronomers look deep into the history of the Universe. Harry Mulisch turns this around and says that images of historical events on Earth are traveling away from us into the dark Universe at the speed of light. The little green men on Mars should be able to see Earth as it was a few minutes ago, and to those who live much further away into the Universe the history of Earth millions or even billions of years ago should be visible. Although we would like to rush after those images, time travel won't help, for one cannot travel faster than the speed of light, unless.... We could look at the light reflected from objects in the Universe! Indeed, Mulisch has the fantastic idea of looking at our own history using the most sensitive telescopes and making images of the light from Earth reflected by interstellar objects back to us! Who would not want to be able to see the history of our planet and its people? Mulisch suggests we should use our most sensitive observatories not so much to

study the history of the Universe but rather the history of Earth. Alas, hardly any light from Earth gets reflected by interstellar objects - the material density of the Universe is too small - but the mere idea is brilliant.

In his *Discovery of Heaven* Harry Mulisch also describes a radio astronomer who suddenly realizes that the strange signals he received might have come from the very spot in the universe where the Big Bang has taken place. That is why signals from this place show more red shift than from anywhere else in the universe and why these signals at first seemed so incomprehensible. The astronomer has discovered the infinitely small, infinitely dense, place of appearance and disappearance, heaven itself. He will not be able to tell his colleagues about his discovery; a stone from heaven kills him instantly. As much as this appeals to our imagination, we will never be able to view the Big Bang in this way. Only from a position outside our universe one might observe the Big Bang as Mulisch imagines it. Unfortunately, we are not in such a position because we are inside this place of appearance, we are not standing outside but we are part of the Big Bang and we see the universe expand around us. We cannot possibly view the expanding universe from outside; it is not the place for humans but for God.

Some twentieth century scientists have taken the place of God and Harry Mulisch believes that it will lead to our disaster. I quote:

*'To the old global disasters are now added the ravaging tidal waves of the new: with their Baconian control of nature, people will finally consume themselves with nuclear power, burn themselves up through the hole they have made in the ozone layer, dissolve in acid rain, roast in the greenhouse effect, crush each other to death because of their numbers, hang themselves on the double helix of DNA, choke in their own Satan's shit.'*

This pessimism is typical for modern literature. Mulisch is not alone: quite a few writers are convinced that, in absence of the steering hand from above, disorder and chaos is the universal trend which is due to a fundamental law of nature. However, as we shall see later, this is not the proper perception of what science teaches us.

For a glimpse of relativity I turned to Alan Lightman's short stories, for the Big Bang to Harry Mulisch's fiction, now for quantum mechanics, the third revolution in modern physics, I prefer drama. In his play *Copenhagen* Michael Frayn introduces three characters: Niels Bohr, his wife Margrethe and his colleague Werner Heisenberg; they represent three issues: quantum mechanics, public perception of science and the making of the bomb.

With quantum mechanics, classical nineteenth century physics came to an end, albeit not abruptly, for it took the two heroes Bohr and Heisenberg three years to make sense of quantum mechanics. Today for most physicists it still seems strange: how can a particle also behave like a wave; how is probability reconciled with causality; what is going on during a physical experiment before the measurement? In conversations between the three actors Frayn conveys the essence and the strangeness of quantum mechanics, the uncertainty or rather the indeterminacy principle.

*‘Bohr: It starts with Einstein. He shows that measurement – measurement, on which the whole possibility of science depends – measurement is not an impersonal event that occurs with impartial universality. It’s a human act, carried out from a specific point of view in time and space, from the one particular viewpoint of a possible observer. Then, here in Copenhagen in those three years in the mid-twenties we discover that there is no precisely determinable objective universe. That the universe exists only as a series of approximations. Only within the limits determined by our relationship with it. Only through the understanding lodged inside the human head.’*

With these words Frayn intimates that according to Bohr and Heisenberg we will never know what matter is nor what it is made of, but this does not prevent us from using quantum mechanics to properly predict the outcome of experiments. For Bohr, however, understanding of physics meant being able to explain it to his Margrethe.

*‘Margrethe: Explain it to me? You couldn’t even explain it to each other! You went on arguing into the small hours every night! You both got so angry!’*

One of the forms of uncertainty touched upon in the play is the uncertainty of human memory, or at any rate of the historical record. Heisenberg’s role in the Second World War becomes the embodiment, the epitome of uncertainty. Has he worked for, or has he sabotaged work on, Hitler’s bomb? That is the question.

*‘Heisenberg: Most interesting. So interesting that it never even occurred to you. Complementarity, once again. I’m your enemy; I’m also your friend. I’m a danger to mankind; I’m also your guest. I’m a particle; I’m also a wave. We have one set of obligations to the world in general, and we have other sets, never to be reconciled, to our fellow-countrymen, to our neighbors, to our friends, to our family, to our children. We have to go through not two slits at the same time but twenty-two. All we can do is to look afterwards, and see what happened.’*

Of course we need textbooks to teach relativity, cosmology and quantum mechanics, but I think together with our students we should also read *Einstein’s Dreams*, *The Discovery of Heaven* and Michael Frayn’s play *Copenhagen*. **By studying science through the looking glass of literature you see the philosophy, history, sociology, ethics and the public perception of modern science.**

At the border between literature, science fiction and suspense we also get a view of science of the twenty-first century. Perhaps the most imaginative in this genre is Michael Crichton. I quote:

*‘He could not have wished a more knowledgeable audience. The Santa Fe Institute had been formed in the mid-1980s by a group of scientists interested in the implications of chaos theory. The scientists came from many fields – physics, economics, biology, computer science. What they had in common was a belief that the complexity of the world concealed an underlying order which had previously eluded science, and which would be revealed by chaos theory, now known as complexity theory. In the words of one, complexity theory was “the science of the twenty-first century.”’*

First in his *Jurassic Park* and then in *The Lost World*, from which this quotation comes, Michael Crichton leaves no doubt about what he considers the science and technology of the future. Just as physics was the science of the twentieth century, life science will be the science of the twenty-first century. Like so many writers Crichton takes side with Mulisch: the genetic engineers through their greed and arrogance will convert the Earth into a frightening game park, leading to chaos and the extinction of humans.

To express his concerns about the developments in twentieth-century science and the end of classical physics, Bertrand Russell (in *The ABC to relativity*) quotes four lines from Lewis Carroll:

*'But I was thinking of a plan  
To dye one's whiskers green,  
And always use so large a fan  
That they could not be seen.'*

The same lines were quoted by Eddington in *The Nature of the Physical World* but with a larger metaphorical meaning: the habit nature apparently has of forever concealing from us her basic structural plan. In the century since Lewis Carroll a whole library of literature has been created representing the role of scientists both in fiction as well as non-fiction, but during this century the optimism of the Enlightenment has disappeared and has been replaced by Postmodern pessimism. The looking glass has stained and darkened considerably, leaving a rather gloomy fragmented and essentially distorted picture.

Modern scientists are literature's least favorite sons. This is the main conclusion of Roslynn Haynes' book *From Faust to Strangelove*, a comprehensive representation of the scientist in Western literature. Drawing on British, American, German, French, Russian, and other examples, Haynes explores the "persistent folklore of mad doctors of science" and its relation to popular fears of a depersonalized, male-dominated, and socially irresponsible pursuit of knowledge for its own sake. She concludes that very few actual scientists – with the exceptions of Isaac Newton, Marie Curie and Albert Einstein – have contributed to the popular image of the scientist. On the other hand, the fictional characters such as Dr. Faustus, Frankenstein, Moreau, Jekyll, and Dr. Strangelove, have been extremely influential in the evolution of the unattractive stereotypes of scientists. Roslynn Haynes argues that this is primarily due to our lack of communication. In her own words:

*'By failing to discuss with nonscientists what they are doing, scientists not only endanger society but limit themselves and their research in a number of ways. They may fail to perceive directions that would be profitable to their work; they may fail to convince funding bodies that what they are doing has any economic or social value; they may be left with no control over what is done with their research; and they will almost certainly be diminished as people.'*

This is all very well and communication is important, but there is more. It is not only the **public** perception of science; it is also the **proper** perception of science that is at stake. In his most recent novel *State of Fear* Michael Crichton mixes fiction with a number of graphical representations of scientific results in one book. Is this the ultimate synthesis of science and literature? Crichton's message comes out loud and clear: **the proper perception of science is essential to the scientist and non-scientist alike**. As Crichton shows, the perception of data on climate change depends very much on your cultural setting. Depending on whether you are in the automobile or oil-industry, or if you are a member of Greenpeace, whether you live in a wealthy nation below sea level or in one of the developing countries, your perception of CO<sub>2</sub> emission data will differ greatly. On top of this there is the willful ignoring of scientific data a particular group does not like.

It will have become clear that, since C.P. Snow, something has changed in our culture. The scientific revolution brought about by Einstein, Lorentz, Bohr, Heisenberg and others has changed our society and our worldview as is reflected also in our literature. Are the basic findings of modern science properly perceived in our culture?

In 1956 C.P. Snow lamented in his *Two Cultures*:

*'A good many times I have been present at gatherings of people who, by standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is about the scientific equivalent of: Have you read a work of Shakespeare's?'*

Then, what about the Second Law of Thermodynamics which should make it as important as Shakespeare's work?

Most people believe the Second Law to say that in nature there is a tendency toward the maximization of disorder, but that is a dramatic mistake! Since C.P. Snow the Second Law is widely quoted in scientific and non-scientific literature. But actually prior to C.P. Snow, already Schrödinger, with his little book *What is Life*, raises the question: how could life come about, how may order emerge from disorder, if the Second Law of Thermodynamics says that in nature disorder is maximized? No wonder C.P. Snow has drawn attention to this; it is a fundamental and enigmatic issue indeed. Also non-fiction writers such as Richard Dawkins, Stephen J. Gould, Peter Atkins, Ilya Prigogine and Brian Greene have basically followed Schrödinger. In numerous articles and books they paint a bleak and pessimistic picture of our future. If nature tends to maximize disorder, according to these authors, evolution is merely a pointless succession of mutations and natural selections in the end leading to nothing but randomness, disintegration and chaos. If famous non-fiction writers send out this message, science journalists will copy them and no wonder the fiction of



modern authors like Michael Frayn, Harry Mulisch and Michael Crichton is as pessimistic and pointless as it is popular today. Since C.P. Snow the two cultures have united and have found a common ground in Postmodern pessimism. In both the sciences and the humanities it is widely believed that, in the absence of Providence, nature's fundamental driving force leads to maximum disorder and chaos; whereas in reality everything in life shows evidence for the contrary.

In contrast to what is commonly thought, the Second Law is not about disorder, and maximizing disorder is not a driving force of nature. The Second Law is about the energy nature requires for it-self in order to increase its freedom of movement. The Norwegian scientist Onsager was the first to draw attention to this, already in the days of Schrödinger. More recent laboratory experiments and computer simulations of structural changes in complex molecular systems have shown increased **order**, such as crystallization, under conditions when the freedom of movement increased. The First Law of Thermodynamics states that energy is conserved, but Nature has the freedom to distribute that energy. It does this in such a way that, according to the Second Law, the total freedom of movement is maximized. In some cases this may lead to disorder, but in other cases it is the opposite and the freedom of movement may increase considerably by ordering, by crystallization. Maximizing freedom of movement is a fundamental driving force in nature. And this force is not only valid in the world of physics, living matter too is subject to the Second Law of Thermodynamics and cells and organisms continuously strive to increase their freedom of movement. A study, recently published in the journal *Science*, indicates that double stranded DNA is increasing its freedom of movement by curling up into the well-ordered double helix structure. Thus maximizing the freedom of movement is one of the fundamental driving forces not only among atoms and molecules, but also in the origin **and** the evolution of life.

Today there is a new separation between cultures. The science/literature polarity is overshadowed by the opposing interpretations of the Second Law of Thermodynamics. On the one hand a rather pessimistic worldview prevails, both in modern science as well as in literature, where it is believed that nature's fundamental driving force leads to maximum disorder and chaos. As we all know humans have been responsible for creating disorder and chaos, particularly in the twentieth century and with the help of scientists. However, the notion frequently expressed in literature that this is legitimated by and almost inevitable because of a fundamental driving force of nature, is unfounded. It is a widely held misconception of the Second Law.

Fortunately there is another, a more positive view supported by recent theory and experiment; it says that nature requires energy in order to maximize its freedom of movement. It should make all the difference in our culture, science **and** literature, if, instead of viewing our world as driven towards disorder, its driving force, its arrow of time, is to increase the freedom of movement.

With this I hope to have cleared the looking glass somewhat. I will finish with one more example. Let us take this ceremony in the Pieterskerk. For the moment you are

all seated in well-ordered rows but at the end of the ceremony you will leave your seats and move to the back of the church for the reception. At that stage, you may call our meeting disordered; on the other hand you could equally well say that our driving force is not to maximize disorder but to increase our freedom of movement, to meet with others, to open new opportunities, to start new relationships, and developments, to progress. Our founding father had an inkling of this also, for you know the motto of Leiden University: *Praesidium Libertatis* (Stronghold of Freedom). Isn't this more optimistic worldview worth celebrating?

Frans W. Saris

### Books quoted

*Einstein's Dreams*, Alan Lightman, Warner Books

*Trots en Twijfel*, Frans W. Saris & Rob Visser, Meulenhoff

*The discovery of Heaven*, Harry Mulisch, Penguin Books

*Copenhagen*, Michael Frayn, Methuen Drama

*Lost World*, Michael Crichton, Ballantine Books

*State of Fear*, Michael Crichton, Harper Collins

*From Faust to Strangelove*, Rosalyn D. Haynes, The John's Hopkins Univ.Press

*The Two Cultures*, C.P. Snow, Rede Lecture

*Through the Looking Glass*, Lewis Carroll, Bramball House

With special thanks to my friends in the "DISPUUT OPGERICHT ZATERDAG 16 NOVEMBER 1946"



